Multi-scale modeling of imperfect interfaces and applications

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2nd International Conference on Multi-scale Computational Methods for Solids and Fluids

MULTI-SCALE MODELING OF IMPERFECT INTERFACES AND APPLICATIONS

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Abstract — In this paper a family of interface models is presented. The derivation of these models is obtained via Homogenization techniques and asymptotic expansions.
Key-words — asymptotic expansions, imperfect interfaces, cracks, finite strain.

1 Introduction

Modeling interfaces between solids is of great importance in the fields of mechanical and civil engineering because the behavior of solid-solid interfaces at the micro-scale has a strongly influence on the strength of many structures at the macro-scale, such as gluing [1], optical systems [2], aircraft tires [3], pavement layers [4] and masonry [5], as example. This lecture is devoted to the modeling of imperfect interfaces i.e. models takes into account a jump in the displacements field and/or a jump in the stress vector due to the interface.

2 Methodology

In this lecture, a deductive approach is used to derive interface models i.e. the thickness of the interface is consider as a small parameter and asymptotic techniques are introduced. A family of imperfect interface models is presented taking into account cracks at micro-scale. The proposed models combine Kachanov [6] or Goidescu et al. [7] homogenization techniques for micro-cracked media in the three-dimensional case, which leads to a cracked orthotropic material, and matched asymptotic method [8,9,10] (see Fig. 1). In particular, it is shown that the Kachanov theory leads to soft interface models and, alternatively, that Goidescu et al. theory leads to stiff interface models. Interface roughness and micro-cracks radius evolution are taken into account in the nearly complete contact condition. A fully nonlinear variant of the model is also proposed, derived from the Saint Venant-Kirchhoff constitutive equation [10,11]. Some applications to elementary masonry structures are presented (see Fig. 2).

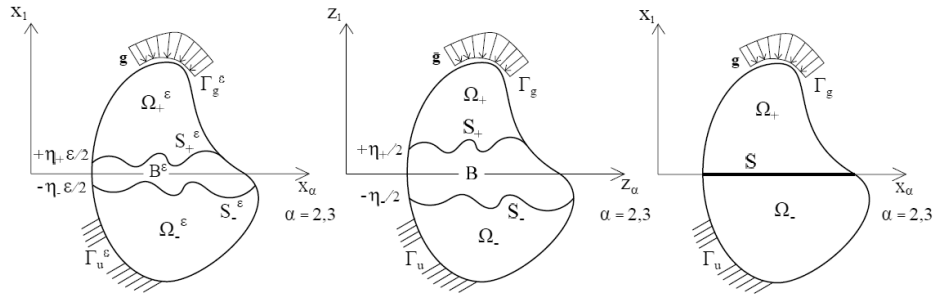

Fig. 1 – Summary of the methodology ($\square_{\pm}$ are function which describe the roughness)
a) Initial b) Rescaling c) Matching

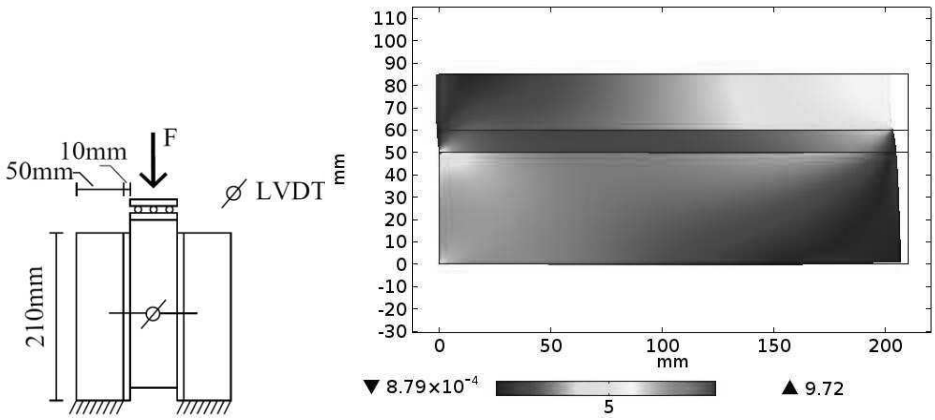

FIG. 2 – Von Mises stresses for an example with three full bricks and four interfaces with roughness (with cosine form)

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